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Statement of inventorship and of right to grant of a patent

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

1. Your reference

DY3007

2. Patent application number
(if you know it)

18 JUL 2002 **0216709.6**

3. Full name of the or of each applicant

ROLLS-ROYCE PLC

4. Title of the invention

AEROFOIL

5. State how the applicant*(s)* derived the right from the inventor*(s)* to be granted a patent

BY VIRTUE OF SECTION 39(1)(a) OF THE PATENTS ACT 1977

6. How many, if any, additional Patents Forms 7/77 are attached to this form? 1
(see note (c))

7. I/We believe that the person*(s)* named over the page *(and on any extra copies of this form)* is/~~are the~~ inventor*(s)* of the invention which the above patent application relates to.

Signature Date

M A GUNN 17.7.2002

8. Name and daytime telephone number of person to contact in the United Kingdom

M A GUNN 01332 249457

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Enter the full names, addresses and postcodes of the inventors in the boxes and underline the surnames

ANTHONY JOHN <u>RAWLINSON</u> 41 GLENWOOD ROAD CHELLASTON DERBY DE73 1UB
Patents ADP number *(if you know it):* 08428260001

Patents ADP number *(if you know it):*

Patents ADP number *(if you know it):*

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18JUL02 E734339-1 D00370
P01/7700 0.00-0216709.6

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Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

1. Your reference

   DY3007

2. Patent application number
   (The Patent Office will fill in this part)

   18 JUL 2002 — 0216709.6

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

   ROLLS-ROYCE PLC
   65 BUCKINGHAM GATE
   LONDON
   SW1E 6AT

   00003970002

   Patents ADP number *(if you know it)*

   If the applicant is a corporate body, give the country/state of its incorporation

   ENGLAND

4. Title of the invention

   AEROFOIL

5. Name of your agent *(if you have one)*

   M A GUNN

   "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

   ROLLS-ROYCE plc
   PATENTS DEPARTMENT
   PO BOX 31
   DERBY
   DE24 8BJ

   Patents ADP number *(if you know it)* 00003962001

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Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

   a) any applicant named in part 3 is not an inventor, or
   b) there is an inventor who is not named as an applicant, or
   c) any named applicant is a corporate body.
   See note (d))

   YES

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	6
Claim(s)	2
Abstract	1
Drawing(s)	1 +1

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10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	2
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	1
Any other documents *(please specify)*	DEPOSIT ACCOUNT FEE SHEET

11. I/We request the grant of a patent on the basis of this application.

Signature M A GUNN Date 17.7.2002

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Aerofoil

The present invention relates to aerofoils and more particularly to appropriate cooling of such aerofoils when cooling channels become blocked.

Aerofoils are used within turbine engines and are subjected to high temperatures such that adequate cooling is required to maintain their operability. Typically, cooling channels are provided through the aerofoil in which coolant, normally air, flows in order to cool the airflow. Unfortunately, these internal cooling channels are prone to blockage by dirt or other contaminants.

Previous approaches to avoiding coolant channel blockage have included channel oversizing, over specifying the number of cooling channels required and incorporation of dirt separation or filtration devices. These approaches inherently result in significant efficiency penalties along with additional fabrication and manufacturing costs.

In accordance with the present invention there is provided an aerofoil for a turbine engine, the aerofoil comprising cooling channels of decreasing cross-section with a transfer passage between adjacent cooling channels in order to provide coolant flow into a channel if normal coolant flow is restricted upstream of the transfer passage.

Preferably, cooling channels are wedge shaped from an inlet to an outlet to provide the decreasing cross-section to coolant flow. Generally, transfer passages will be provided in both sides of each cooling channel. Normally, the or each transfer passage cross-section accumulation is determined for substantial conformity with their coolant channel outlet cross-section for coolant flow balance through the aerofoil. Possibly, more than one transfer passage will be provided between adjacent cooling channels. Typically, transfer passages will have a one millimetre diameter. Possibly, transfer passages are staggered to

improve heat transfer and/or mechanical strength in the aerofoil. Normally, transfer passages are located towards an upstream end of each cooling channel. Possibly, the relative cross-section and distribution of transfer passages between adjacent cooling channels and/or through the length of the aerofoil may be different in order to facilitate desired cooling of the aerofoil.

Also in accordance with the present invention there is provided a turbine engine including an aerofoil as described above.

An embodiment of the present invention will now be described by way of example only with reference to the accompanying drawing, Figure 1, which is a schematic representation of cooling channels in an aerofoil.

Referring to the drawing Fig. 1 which provides a schematic representation of an aerofoil 1 including cooling channels 2,3,4,5. Generally, the cooling channels 2,3,4,5, have a wedge configuration such that an inlet end 6 has a significantly greater cross-section than an outlet end 7. Thus, each of the cooling channels 2,3,4,5 has a decreasing cross-section presented to an airflow in the direction of the arrowheads. The rate of coolant airflow (arrowheads A) through the channels 2,3,4,5 will be dependant upon turbine engine speed and cooling requirements. It will be appreciated that heating of the aerofoil 1 will be dependant upon turbine engine operation or condition and so the degree of cooling required may be variable. Nevertheless, the aerofoil 1 will typically require on-going cooling whilst operational and any failure will compromise aerofoil performance.

In the present aerofoil 1 transfer passages 8 are provided between adjacent cooling channels 2,3,4,5. In normal use, as a result of the equalisation of airflow pressure in the adjacent channels 2,3,4,5 there will be negligible, if any, transfer airflow through the passages 8 and therefore between the channels 2,3,4,5. However, when

a channel such as cooling channel 4 is blocked by a blockage 9 there is a diminution in the flow pressure in that channel 4 if only partly blocked or an absence of coolant airflow pressure if completely blocked. In such circumstances, the coolant airflow pressure in adjacent coolant channels 3,5 will force air through the passages 8 in the direction of arrowheads B in order to provide cooling in that channel 4. The effective constriction in the channels 3,4,5 due to decreasing cross-section effectively pressurises the coolant airflows in these channels 3,4,5 and the desire to equalise pressure through the passage 8 substantially drives air into the channel 4 and renders any venturi effect due to the airflow past the passage 8 in the respective channels 3,5 irrelevant.

It will be noted that airflow in channel 2 may not be driven through the respective passage 8 between that channel 2 and its adjacent channel 3 if there is substantially the same airflow pressure in these channels 2,3. However, if the leakage of air though the respective passage 8 between channels 3 and blocked channel 4 is sufficient to diminish the flow pressure in channel 3 then the balance in airflow pressure between channel 2 and channel 3 will be disturbed and there may be some airflow through the respective passage 8 between the channels 2,3 to compensate. There may be a cascade of transfer airflow in the passages 8 progressively decreasing away from the blocked channel.

As can be seen in Fig. 1 transfer passages 8 are provided on either side of central coolant channels 2,3 whilst outer coolant channels 2,5 only have one transfer passage 8 with their adjacent coolant channel 2,3. In such circumstances, central coolant channels 2,3 can receive coolant airflow through respective passages 8 from either adjacent channel when blocked whilst outer channels 2,5 will only receive coolant flow through one passage 8 when blocked. This situation may be acceptable if the outer

portions of the aerofoil 1 are subjected to less heating and therefore less coolant is required in the outer channels 2,5. Alternatively, these outer coolant channels 2,5 could incorporate more than one transfer passage with adjacent coolant passages in order that potentially greater coolant flow may pass through these additional transfer passages to improve cooling. Nevertheless, it will be appreciated that by having a wedge cross-section configuration each channel 2,3,4,5 is diminishing from its inlet end 6 to its outlet end 7 so that it may be difficult to accommodate several transfer passages in the length of the channels 2,3,4,5. Furthermore, it should be appreciated that incorporation of transfer passages should not appreciably diminish the mechanical strength of the aerofoil 1.

As illustrated in Fig. 1, typically the transfer passages 8 will comprise round holes between adjacent channels 2,3,4,5. Normally, these holes will have a diameter of approximately 1 millimetre. Alternatively, the transfer passages may have different cross-sections including oval, lozenge or square.

Retention of mechanical strength in the aerofoil is important. Thus, in order to break any potential structural lines of weakness, the transfer passages in adjacent channels may be staggered out of alignment with each other. Furthermore, rather than being axially aligned within the aerofoil 1 each passage could be slanted relative to the major axis of the aerofoil to facilitate flow guidance or scoop pickup when required between adjacent coolant channels due to a blockage of one or more such coolant channels. Furthermore, these passages could have a herringbone or arrowhead arrangement of intersecting slope sections to the major axis of the aerofoil 1.

As indicated previously, accommodation of the transfer passages 8 may be difficult due to the thin nature of the aerofoil 1 and compounded by the wedge cross-section

configuration. Thus, normally the transfer passages 8 will be located towards an upstream end of the coolant channels 2,3,4,5, that is to say towards the inlet ends 6.

The cross-section provided by respective transfer passages 8 will typically be determined for substantial conformity with the outlet end 7 cross-section of each coolant channel 2,3,4,5. Such an arrangement should ensure coolant flow balance between the respective coolant channels 2,3,4,5. In such circumstances, the aerofoil 1 will be substantially cooled throughout its length with substantially the same or a desired cooling effect through each of the channels 2,3,4,5 irrespective of blockage 9.

As indicated previously, transfer passages 8 during normal open operation for all channels will be redundant in terms of limited, if any, transfer airflow between the channels. In such circumstances, the relatively high pressure and airflow rates through the channels along with the perpendicular presentation of that airflow should limit the possibility of dirt blocking these transfer passages 8. In any event, if the transfer passage 8 was substantially blocked during normal operation this blockage would not be compacted and so should be relatively loose. Furthermore, if any inlet end were blocked then there would be no back up pressure behind such a loose blockage in a transfer passage and the adjacent airflow pressure may drive the blockage out or through the transfer passage and out of the blocked channel.

The present aerofoil 1 will generally be used in a turbine engine. The operation of turbine engines is well known by those skilled in the art. It will be appreciated that aerofoil fins are subjected to substantial heating during their operation but are required to retain substantially consistent structural configuration and strength. In such circumstances, an aerofoil must remain within specified temperature ranges in order to retain structural conformity and strength for consistent turbine

engine operation. Blockage of cooling channels as described previously will alter cooling within the aerofoil both collectively and locally about the blocked cooling channel. In such circumstances, the aerofoil may rapidly deteriorate in operation and require potentially expensive replacement. The present invention also includes a turbine engine including an aerofoil as described previously such that greater confidence can be provided that each individual aerofoil will be adequately cooled such that planned and preventative replacement of aerofoils for operational confidence can be extended over longer periods of time or service history.

Whilst endeavouring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

Claims

1. An aerofoil for a turbine engine, the aerofoil comprising cooling channels of decreasing cross-section with a transfer passage between adjacent cooling channels in order to provide coolant flow into a channel if normal coolant flow is restricted upstream of the transfer passage.

2. An aerofoil as claimed in claim 1 wherein the cooling channels are wedge shaped from an inlet to an outlet to provide the decreasing cross-section to coolant flow.

3. An aerofoil as claimed in claim 1 wherein transfer passages are provided on both sides of each cooling channel.

4. An aerofoil as claimed in any of claims 1,2 or 3 wherein the transfer passage has a cross-section determined for conformity with the outlet cross-section of a respective coolant channel for substantial coolant flow balance across the coolant channels of the aerofoil.

5. An aerofoil as claimed in any preceding claim wherein more than one transfer passage is provided between adjacent coolant channels.

6. An aerofoil as claimed in any preceding claim wherein each transfer passage has a diameter of approximately 1 millimetre.

7. An aerofoil as claimed in any preceding claim wherein each transfer passage has a round or lozenge or oval cross-section.

8. An aerofoil as claimed any preceding claim wherein each transfer passage is substantially perpendicular to the respective coolant channels between which it extends.

9. An aerofoil as claimed in any preceding claim wherein the transfer passages are staggered relative to the major axis of the aerofoil in order to improve heat transfer and/or mechanical strength of the aerofoil.

10. An aerofoil as claimed in any preceding claim wherein each transfer passage is located towards an upstream end of its coolant channel.

11. An aerofoil substantially as hereinbefore described with reference to the accompanying drawing.

12. A turbine engine including an aerofil as claimed in any preceding claim.

13. Any novel subject matter or combination including novel subject matter disclosed herein, whether or not within the scope of or relating to the same invention as any of the preceding claims.

Abstract

Aerofoil

An aerofoil 1 includes cooling channels 2,3,4,5 with transfer passages 8 between adjacent channels 2,3,4,5. In normal operation, the constriction in each cooling channel 2,3,4,5 ensures direct through coolant airflow in the direction of arrowheads A. However, when a channel 4 is blocked by a blockage 9 airflow in adjacent channels 2,5 is forced through the transfer passages 8 in order to provide airflow in the blocked channel 4 and facilitate cooling. This blocked channel airflow is in the direction of arrowheads B. Generally, the cross-section of the transfer passages 8 is determined for conformity with the outlet 7 cross-section of the channel 4 in order to achieve substantial coolant flow balance across the coolant channels 2,3,4,5 of the aerofoil 1.

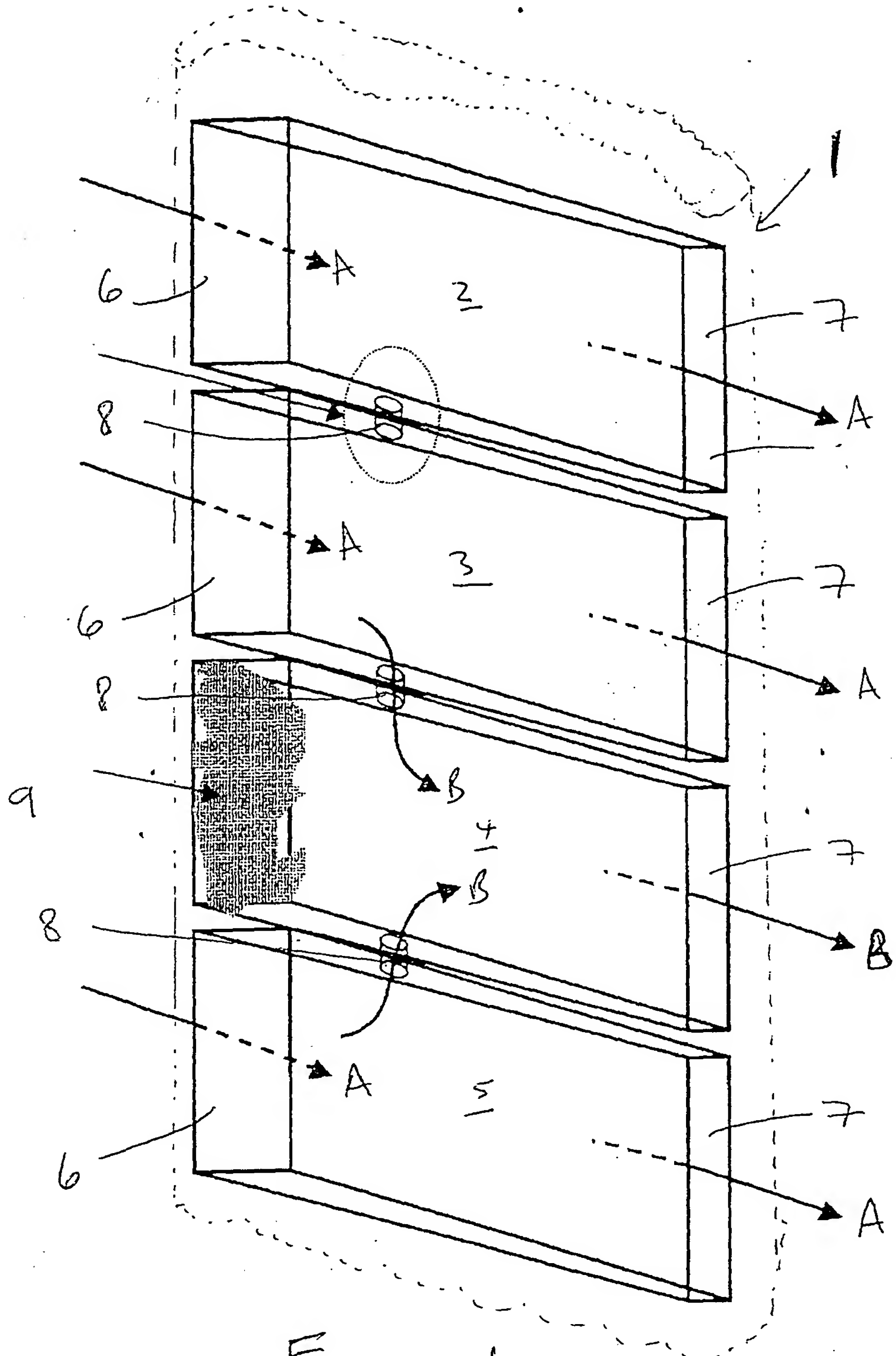

Figure 1